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RESEARCH ARTICLE

Typology of Milk Producing Households in Maharashtra: Explaining Use of Animal Husbandry Practices and Dairy Herd Productivity

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ABSTRACT

Multivariate typology is a valuable tool in exploring farming systems, facilitating effective communication for the target farmers with their varied needs. The use of practices and dairy herd productivity may vary according to their socio-personal and farm-specific attribute. In heterogeneity, developing unique recommendations and interventions for milk-producing households will be very difficult. The present ex-post facto study was conducted to identify homogenous clusters and assess animal husbandry practices use and dairy herd productivity across different identified clusters. The data was collected from 240 milk-producing households, equally divided across three selected districts, through personal contact using a pre-tested interview schedule. The respondent was - a person belonging to such milk-producing households- who had control over decision-related dairy farms and operations. Two multivariate techniques i.e. Principal component analysis (PCA) and cluster analysis (CA) were used. Four distinct clusters were identified with significant heterogeneity with their socio-personal and farm-specific attributes. More land-owning young and educated farmers in Cluster 1 used more animal husbandry practices than in other clusters and obtained significantly higher milk productivity than households in Cluster 2. Most milk-producing households with large herds and trained farmers (C3) and resource-poor milk-producing households in Cluster 2 and Cluster 4 received a medium level of milk productivity.

***Keywords**: Typology; Milk-producing households; Dairy herd productivity.*

In India, the milk production was recorded 221.06 million tons during 2020-21 (*BAHS, 2022*). Despite being the world's largest milk producer, the productivity of Indian livestock is among the lowest in the world. The reasons for low productivity largely attributed to the traditional dairy system and no adoption of the improved management practices at the desired level (*Sharma and Kumar, 2004*). Breed deterioration, rise in the population of non-descript animals, chronic shortage of feed and fodder, poor management practices *etc*. (*Patil et al., 2009*) are also the explanations for low productivity. It is well recognized that economic viability in milk production may vary across different dairy systems categorized on the basis of relevant socio-economic and farm characteristics of milk-producing households. Indian smallholder farming systems are highly complex and heterogeneous in their characteristics (*Kumar et al., 2019*). Livestock technology use may vary among farm households because of differences in socioeconomic characteristics (*Somda et al., 2005; Milan et al., 2006*). It is well recognized that for increasing productivity and production with an aim to make dairy farming more remunerative, it is essential to go for using livestock technologies in the field of breeding, feeding, health care and management. It is difficult to develop unique recommendations, technologies, educational programs, and policy interventions for each household in such circumstances. A more objective classification of livestock enterprises is needed to reveal the main factors that dictate the level of intensity in their production system (*Gelasakis et al., 2012*). Typological studies can be of great importance for exploring factors explaining adoption of new technology *(Kostrowicki, 1977*). Multivariate analysis may be a useful tool in planning extension activities and using communication channels effectively for the target farmers with varied needs, constraints and motivation for change (*Martínez-García et al., 2015*). Less research attention has been given in order to analyse the level of homogeneity of milk producing households and farm in the Marathwada region of Maharashtra state. In this context, the present study was carried out to assess use of animal husbandry practices and dairy herd productivity across different identified clusters.

METHODOLOGY

The present *ex-post facto* cross-sectional research study was conducted purposively in Southern districts of the Marathwada region in Maharashtra state including three districts *viz*. Latur, Dharashiv and Beed. Two tahsils from each district, five villages from each tahsil, and eight milk-producing households from each village were randomly selected. Thus, a total of 240 households, equally divided (each 80) across three selected districts, formed the sample size. The respondent was - a person belonging to such milk-producing households- who had control over decision - related dairy farms and operations. A field survey was conducted during October to December 2022 using a pre-tested interview schedule. The socio-personal and farm specific data was collected. Fourteen animal husbandry practices related to housing, feeding, breeding, health and management were included in the schedule. Responses for each practice were recorded on a three-point continuum scale, viz. frequently, sometimes, and never, with the corresponding codes of 3, 2, and 1. To measure the milk productivity, the milk yield index was computed based on the procedure suggested by *Yang (1980).* The milk yield index compared the yield of all dairy animals owned by milk-producing households to the regional average milk yield. The responses were recorded about the number of dairy animals, average daily milk yield (litres), and average lactation length (in days) on the recall basis of respondents. Collected data was edited and tabulated. The cumulative square root rule (*Dalenius and Hodges, 1957*) was used to construct class for equal and proportional allocation of variables.

Milk-producing household typologies were constructed by following the methodology described by *Bidogeza et al. (2008), Garcia et al. (2012*), and; Baral and Bardhan (2016) using two multivariate statistical techniques, Principal Component Analysis (PCA) and Cluster Analysis (CA). Gretl and SPSS 2020 software were used for data analysis. PCA used to linearly transform an original set of 14 variables (Table 4), representing personal-family specific eight and farm specific six variables, into a smaller set of uncorrelated variables (factors) representing most of the information in the original set. The decision regarding the number of factors to be retained was based on Kaiser's criterion that suggests retaining all factors with eigenvalues greater than 1. Six principal components emerged with eigenvalues greater than one, which explained a cumulative 68.76 per cent of total original variability (Table 1). Bartlett's sphericity test (Table 2) was highly significant ($p<.01$), which indicated the use of PCA towards dimension reduction,

Table 1. Correlation matrix (PCA)

Component	Eigenvalue	Proportion	Cumulative
1	2.5717	0.1837	0.1837
2	1.9916	0.1423	0.3259
3	1.6294	0.1164	0.4423
4	1.2767	0.0912	0.5335
5	1.1514	0.0822	0.6158
6	1.0059	0.0719	0.6876
7	0.8838	0.0631	0.7508
8	0.7830	0.0559	0.8067
9	0.7117	0.0508	0.8575
10	0.5819	0.0416	0.8991
11	0.4387	0.0313	0.9304
12	0.4097	0.0293	0.9597
13	0.3167	0.0226	0.9823
14	0.2476	0.0177	1.0000

Table 2. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.555
Bartlett's Test of Sphericity	Approx. Chi-Square	701.897
	df	91
	Sig.	.000

Table 3. Nomenclature of clusters

Cluster	Cluster name	No. of households	% of households
Cluster 1	More land-owning, high employment and high income, large-sized households with young and educated farmers	14	5.83
Cluster 2	Resource-poor, low-income generating large-sized households with old farmers	52	21.67
Cluster 3	Large herd and less land-owning high-income households with trained farmers	68	28.33
Cluster 4	Resource-poor, low employment and low income small-sized households with few earners	106	44.17

is justified. The factors retained from the PCA were used to form clusters. To determine the optimal number of clusters, a hierarchical cluster analysis using Ward's method and squared Euclidean distance carried out to classify the milk-producing households based upon agglomeration schedule. The agglomeration schedule provides changes in the coefficients as the number of clusters increases, and those changes enabled in determination of optimum number of clusters, i.e., 4 clusters. Using K-mean clustering, milk-producing households were then divided into four clusters. Finally, a one-way ANOVA and post-hoc Tukey HSD tests were used to determine whether these clusters had statistically significant differences and were named as shown in Table 3.

RESULTS AND DISCUSSION

Cluster differentiation based on socio-personal and farm specific attributes : More land-owning high-income households (C1) scored significantly low on average age (Table 4) compared to resource-poor, low-income large-sized households in cluster 2. However, milk producing households in cluster 1 scored significantly high on 'education,' 'land holding,' and 'hired labour involvement in dairy farming' compared to other clusters. The mean rank and median of education level was the highest in more land-owning high-income households (C1), and lowest in resource-poor, low income large-sized households (C2). Average agricultural land holding of households in C1 was 13 acres with significantly higher average hired labour (1.79 number) use than other clusters, possibly due to more extensive agriculture land holdings and subsequent requirements for multiple tasks including dairy farm operations. More land-owning households with young and educated farmers in C1 and large herd and less land-owning households with trained farmers in C3 scored significantly high on gross annual income compared to other clusters. Herd size scored significantly low in resource poor households belonging to cluster 4 compared to households in C1 and C3. A large herd and less land-owning high-income households in cluster 3 had a significantly high average herd size compared to resource poor households belonging to cluster 2 and 4. However, they were not significantly different from more land-owning high-income households (C1).

Large herd and less land-owning high-income households with trained farmers largely belonging to nomadic tribes (C3) scored significantly high in training participation compared to other clusters. A few private firms, non-government organizations, or animal husbandry departments might have intensively offered some social group-targeted dairy-related training in certain pockets of the study area. Resource-poor households in Cluster 2 scored significantly high in family labour involvement, while resource-poor households in cluster 4 scored significantly low on the same factor. It might be due to the significant variations in household size between them. In cluster 2 and 4, milk-producing households mostly belonged to other backward classes. In contrast, in cluster 1, they dominantly belonged to the general category, and in cluster 3, most households belonged to nomadic tribes. In cluster 4, household size and earning members in households scored significantly low compared to other clusters, and employment generation in dairy farming was also significantly low among them compared to cluster 1 and 2. No significant differences were observed in the sex of respondents and animal shed score of milk-producing households across all clusters.

Use of animal husbandry practices : The use of animal husbandry practices (Table 5) elicited that the overall majority (55.8%) of the milk-producing households used animal husbandry practices at medium extent. However, one-fourth of milk producing households were using high extent of animal husbandry practices in their dairy farms, while 18.8 per cent used animal

Table 4. Variables used for cluster formation, its mean/median values and statistical differences across clusters

Variables	Measurements (code)	Mean±SD / Median (Mean rank)				F (p)/ χ^2 (p)
		C1	C2	C3	C4	
Age of respondent (Years)	Chronological age of respondent in completed years	$41.93^{b}\pm11.65$	$53.94^{a}\pm9.80$	$47.87^{ab}\pm10.96$	$47.08^{ab}\pm11.74$	F 6.425 (.000)
Sex of respondent	*Male (1) or Female (2)	1 (90.00)	1 (122.31)	1 (130.59)	1 (117.17)	χ^2 7.767 (.051)
Education of respondent	*Illiterate (1) /Primary (2) /Middle (3) /High School (4) / Intermediate (5) /Graduate (6)	5.5 (214.64)	3 (104.72)	3 (123.19)	3 (114.08)	χ^2 31.69 (.000)
Social group	*NT (1) /ST (2) /SC (3) /OBC (4) /General (5)	5 (148.39)	4 (150.14)	1 (64.12)	4 (138.44)	χ^2 68.266 (.000)
Household size (No.)	Total number of members in household	$5.86^{a}\pm.95$	$6.13^{a}\pm1.17$	$5.19^{b}\pm.90$	$4.56^{c}\pm.72$	F 39.179 (.000)
Earning members (No.)	Total number of earning members in household	$2.07^{a}\pm.62$	$2.35^{a}\pm.51$	$2.09^{a}\pm.48$	$1.48^{b}\pm.50$	F 40.038 (.000)
Household income (Lakh Rs)	Annual gross income in Rupees obtained by all household members through farm and non-farm sources	$8.33^{a}\pm4.82$	$6.02^{b}\pm1.85$	$8.78^{a}\pm2.57$	$4.68^{b}\pm1.44$	F 52.437 (.000)
Training participation	*Yes (1) / No (0)	0 (116.14)	0 (99.00)	1 (166.06)	0 (102.40)	χ^2 94.133 (.000)
Land holding (Acres)	Actual land owned in acres	$13.14^{a}\pm5.78$	$4.12^{b}\pm2.16$	$5.53^{b}\pm2.65$	$4.07^{b}\pm2.10$	F 18.222 (.000)
Herd size (SAU)	Standard Animal Unit (Sirohi et al. 2019)	$11.21^{ab}\pm5.59$	$9.54^{bc}\pm3.11$	$12.31^{a}\pm2.60$	$8.69^{c}\pm3.28$	F 52.970 (.000)
Animal shed (Score)	Animal shed score	10.43±2.76	9.98±2.10	10.03±1.95	9.47±1.65	F 2.027 (.111)
Family labour involvement (No.)	Number of family labour involved in dairy farming	$2.14^{b}\pm.95$	$2.56^{a}\pm.61$	$2.24^{b}\pm.43$	$1.81^{c}\pm.42$	F 27.029 (.000)
Hired labour involvement (No.)	Number of hired labour involved in dairy farming	$1.79^{a}\pm.70$	$1.00^{b}\pm.34$	$1.07^{b}\pm.26$	$.99^{b}\pm.22$	F 28.927 (.000)
Employment generation (Man-days)	Time spent for different dairy activities in Man-days	$232.62^{a}\pm56.87$	$218.09^{a}\pm40.57$	$213.32^{ab}\pm48.39$	$188.61^{b}\pm39.56$	F 9.276 (.000)

*Qualitative variables coded and median and mean rank used for analysis.

Quantitative and qualitative variables were tested using One way ANOVA and Kruskal Wallis H test, respectively.

Values with different superscript are significantly different.

husbandry practices at low level. Majority of more land-owning high-income households (C1) used practices at high level, while most milk producing households in other clusters used practices to a medium extent. There was a significant difference in the use of animal husbandry practices across the clusters. More land-owning high-income households (C1) scored significantly high on the 'use of animal husbandry practices' compared to resource-poor households (C2 and C4) and large herd-owning households in cluster C3.

Dairy herd productivity : In maximum (45.4%) milk-producing households, the milk productivity of dairy animals was medium level, followed by low milk productivity in nearly one-third of households as shown in Table 5. High extent of dairy herd productivity revealed in about 21 percent of milk-producing households. The overall average milk productivity index was 98.6 percent. Medium level of milk productivity of dairy herd was noticed among majorities in resource-poor low-income households (C2 and C4), and large herd-owning high-income households (C3). The majority (42.9%) of more land-owning high-income households (C1) equally distributed in high and low level of milk productivity. There was a significant difference in mean milk productivity indices across all the clusters. Resource-poor low-income large-sized households (C2) were significantly low in average milk productivity indices (92.4%) than the average milk productivity (111.1%) of more land-owning high-income households (C1).

Multivariate analysis is very useful tool in classifying dairy farming system more objectively in view to select need based technologies or practices suitable to particular farming system and implementation of extension educational programme effectively considering the target audience. Four distinct heterogeneous farming systems of milk producing households revealed in study area based upon socio-personal, household and farm-specific characteristics.

Land-owning high-income households (C1) have a significantly lower average age compared to resource-poor low-income households (C2). This contradicts the findings of *Nazir and Kharkwal (2017)*, who reported that older farmers tend to have higher incomes. However, it suggests that younger farmers with more resources might be entering dairy farming, potentially due to factors such as inheritance or access to credit.

Milk producing households in C1 have significantly higher education levels compared to other clusters. This suggests that education plays a role in improving income in dairy farming, perhaps by enabling farmers to adopt better practices, manage their finances more effectively, and access new markets. Similar findings were reported by *Pathade et al. (2022)*.

Land-owning households (C1) have significantly higher land holding and hired labour use compared to other clusters. This is likely due to the economies of scale that come with larger farms, as well as the need for more labour to manage larger herds and operations. These factors also contribute to higher gross annual income in C1.

Large herd and less land-owning households in C3 have a significantly higher average herd size compared to resource-poor households. However, they are not significantly different from more land-owning high-income households (C1). This suggests that herd size plays a role in income, but it is not the only factor. Other factors, such as land quality, access to markets, and management practices, also likely play a role.

Table 5. Extent use of animal husbandry practices and milk productivity across all clusters

Variables	Class interval	C1 (n=14)	C2 (n=52)	C3 (n=68)	C4 (n=106)	Overall (N=240)	F (p)
Use of AH practices (Score)	Low (22 to 25)	0 (0.00)	8 (15.4)	7 (10.3)	30 (28.3)	45 (18.8)	8.712 (.000)
	Medium (26 to 29)	4 (28.6)	34 (65.4)	42 (61.8)	54 (50.9)	134 (55.8)	
	High (30 to 36)	10 (71.4)	10 (19.2)	19 (27.9)	22 (20.8)	61 (25.4)	
	Mean±SD	30.57^{a}±2.62	27.58^{b}±2.46	28.34^{b}±2.37	27.22^{b}±2.62	27.81±2.64	
Milk productivity (Indices)	Low (47.80-82.92)	6 (42.9)	22 (42.3)	13 (19.1)	40 (37.7)	81 (33.8)	3.392 (.019)
	Medium (82.93-118.04)	2 (14.2)	23 (44.2)	37 (54.4)	47 (44.4)	109 (45.4)	
	High (118.05-223.40)	6 (42.9)	7 (13.5)	18 (26.5)	19 (17.9)	50 (20.8)	
	Mean±SD	111.1^{a}±46.0	92.4^{b}±23.2	104.6^{ab}±21.6	96.1^{ab}±28.2	98.6±27.2	

Figures in parenthesis indicate percentage; Values with different superscript are significantly different

The nomadic tribes' households in C3 with large herds and less land, but trained farmers, have high training participation is interesting. This suggests targeted training programs by private firms, NGOs, or animal husbandry departments are reaching specific social groups. More research is needed to understand the motivations behind these programs and their effectiveness in improving dairy farming outcomes for these communities.

Resource-poor households in C2 having high family labour involvement suggests they rely heavily on family members for farm work due to resource constraints. This highlights the importance of policies that support these households, such as providing access to labour-saving technologies.

The significantly low family labour involvement in resource-poor C4 households, despite having smaller families and earning members, is puzzling. Further investigation into the reasons for this low involvement is needed. It could be due to factors like outmigration of working-age members, lack of interest in dairy farming among younger generations, or cultural norms regarding labour participation.

The observation that milk producers in different clusters belong to different castes (OBCs in C2 & 4, General category in C1, and nomadic tribes in C3) suggests potential caste-based differences in dairy farming practices and resource access. Further research exploring these differences and their impact on farm income and sustainability is crucial.

The significantly lower household size, earning members, and dairy farming employment in C4 compared to other clusters indicate a stark economic disparity. Targeted interventions are necessary to address these inequalities and improve the livelihoods of these households.

The absence of significant differences in the sex of respondents and animal shed scores across clusters suggests gender may not be a major factor influencing dairy farming practices in this context. However, further investigation into gender roles and decision-making within households within each cluster could reveal nuances.

These results highlight the complex interplay of social, economic, and cultural factors influencing dairy farming practices and income across different groups. Further research delving deeper into these factors and their interactions would be valuable for designing effective policies and interventions to support sustainable and equitable dairy development in the region.

The study provides valuable insights into the relationship between various factors and income in dairy farming. More land, education, hired labour, and larger herd size are associated with higher income. However, the specific relationships are complex and vary depending on the context. Further research is needed to understand these relationships in more detail and develop targeted interventions to support dairy farmers.

The majority of households use animal husbandry practices to a medium extent is consistent with previous studies [*Khode et al. (2009), Khode et al. (2017), Kumar et al. (2017)* and *Randhave et al. (2022)]*. This suggests a widespread awareness and adoption of basic practices, but room for improvement in some areas. The presence of a significant portion using practices at a high level indicates a positive trend towards advanced management, potentially driven by factors like higher income and larger landholdings. The use of low-level practices highlights the need for targeted interventions to address knowledge gaps and resource constraints in these households.

The association between landownership, income, and higher use of animal husbandry practices aligns with observations by *Nazir and Kharkwal (2017)*. This suggests that resource availability plays a crucial role in adopting more advanced practices. More land-owning high-income households (C1) scoring significantly higher than resource-poor groups (C2, C4) and large herd-owning C3 reinforces this link. This raises questions about potential equity concerns in access to resources and knowledge. The higher adoption in C1 could be due to factors like better access to extension services, and financial resources to invest in improved practices and technologies. Resource constraints and lack of access to knowledge and support systems might be limiting factors for low-income and resource-poor households.

The finding that 45.4 per cent of households have "medium" milk productivity, followed by 33% with "low" productivity and 21 per cent with "high" productivity paints a picture of a diverse landscape with potential for improvement. This aligns with previous research by *Yadav et al. (2014)* and *Khode et al. (2020)*, suggesting a regional trend. The observation that "medium" productivity dominates in resource-poor households (C2, C4) and large-herd, high-income households (C3) highlight a potential link between resource availability and productivity levels. This is further supported by the significantly lower average milk productivity in resource-poor households (C2) compared to high-income ones (C1). This disparity raises concerns about equitable access to resources and knowledge that could improve productivity. Interestingly, the majority of high-income households (C1) are split between "high" and "low" productivity, suggesting factors beyond just resources influencing performance. This could be related to management practices, breed selection, access to specific technologies, or other variables.

The results suggest a need for interventions tailored to different groups:

Resource-poor households: Providing access to improved breeds, nutrition, and veterinary care could significantly enhance productivity.

Large-herd households: Optimizing herd management practices, adopting better breeding strategies, and utilizing technologies could improve efficiency.

High-income households: Investigating the factors differentiating high and low productivity within this group could yield valuable insights for broader improvement.

CONCLUSION:

Multivariate typology identified four distinct clusters of milk-producing households. Significant heterogeneity was observed in these households regarding their socio-personal, household, and farm-specific characteristics. More land-owning, high employment and income, and large-sized households with young and educated farmers (C1) had significantly higher use of animal husbandry practices than other clusters. More land-owning households in Cluster 1 also had significantly higher milk productivity than resource-poor milk-producing households in Cluster 2. Most milk-producing households with large herds and trained farmers (C3) and resource-poor milk-producing households in Cluster 2 and Cluster 4 had a medium extent of milk productivity. Overall, across all the clusters, there is a vast scope to enhance the milk productivity of dairy animals by improving their use of animal husbandry practices. More inclusive and impactful training approaches could enhance the usage of animal husbandry practices. Policymakers and extension agencies should consider the heterogeneity in designing and delivering extension interventions that are likely to be more effective.

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